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Urban mobility data management – the OPTICITIES project and the Madrid standardization proposal

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Abstract

Urban mobility is an increasingly complex challenge for the cities, and involves many different aspects. An aspect central to the problem is the management of mobility data in the cities. The traditional approach has resulted in data silos implemented and mostly valid only for the city for which they were developed.
The OPTICITIES project aims at providing a common framework for multimodal transport management and service provision in the urban environment. A thorough analysis of all the relevant aspects related to the urban data management will be performed in a number of European cities. Working on the idea of local implementations, an overall interoperability framework and local data management profiles of data formats and interfaces are being defined and tested. Working closely with ISO and CEN standardisation groups, it is expected that OPTICITIES will impact directly on reference standard drafts.
Additionally, cities usually present also particularities that cannot be addressed exclusively from a technical point of view. The city and region of Madrid, Spain, has done a huge effort in order to integrate operators' data in a common platform, but needs to consider legacy and new systems, and other factors. The OPTICITIES project aims to integrate all these factors into an implementation guidelines handbook that will allow any city, regardless of the currently used systems and applications, to address the deployment of advanced multimodal data management elements.

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1. Introduction

Mobility stakes are increasingly important in today's fast-growing urban centres all over the world, but particularly in the European Union where 75% of inhabitants live in urban areas. The21st century is indeed the century of cities where we also find the bulk of economic development and innovation potential.

The challenges faced by cities and metropolitan areas can be considered as a five-dimension prism with the following dimensions: Accesibility, Environment, Urban areas quality of life, Urban freight and Public space management.

After forty years of massive investments, infrastructure networks inter-connections have become a priority to ensure urban population growth and economic development. This was introduced in transport public policies through the concepts of inter-modality, multimodality and co-modality. Moreover in the 1990s information and communication technologies applied in the transport fields allowed the deployment of network management systems and user information services.

Conclusions drawn from these previous investments are rather positive but still modest in light of the long term modal shift objectives. These objectives require strong and coordinated actions. Implementation plans should gather a large range of cooperating stakeholders from every transport mode at local or regional level to emphasize the effects on the network and users.

At the same time environmental and financial constraints have greatly limited the capacity to build new transport infrastructure. Thus a new logic based on a service approach and on the optimization of existing infrastructure has emerged to meet the increasing mobility demand.

2. The case of Madrid public transport system

In the case of Madrid region, public transport system is made up of over 40 public and private operators with a wide range of transport services and infrastructures.

The Consorcio Regional de Transportes de Madrid (CRTM) is the single Transport Authority in charge of coordinating all these companies and it establishes the conditions under which services must be provided to clients. The majority of public transport users are multimodal passengers (over 50%) who need dynamic, timely information at system level, in order to optimize their trips. Other reason that has increased the tendency to multimodality between Madrid PT users has been the implementation of a travel pass which allows users to take any transport mode for the same price. Over 70% of trips on PT is done using this multimodal travel pass.In this context, multimodal information in real-time is an increasing demand to which the CRTM must respond.

In the case of Madrid, CRTM, has taken several steps to tackle these challenges. The main step has been the creation of a Smart Mobility Management Center, CITRAM. Fully operational from August 2013, CITRAM supervises on real time the public transport system of the whole region. It is a project lead by CRTM in which all the 40 companies involved in PT, have collaborated. CITRAM allows, with an intensive use of ICTs, improving coordination and supporting decision making.

An important part of the data management structure of the CITRAM was the development of a multimodal toolkit that integrates all the data from different transport modes in the same platform. This effort goes in line with that of many other cities, trying to harmonize the information available to the transport manager. Moreover, there has been lately an interest from the European Commission to promote this harmonization, as current urban data management systems in the cities have been implemented according to each city's needs and environment.

3. Current urban data management initiatives

There are two areas in which data management initiatives have resulted in very different approaches to the data management: collected and stored data contents and formats, and data provision system architectures.

Various existing or under development standards are used by the cities, in relation to public transport (Transmodel (CEN, 2006), SIRI (CEN, 2011b), NeTEx (CEN, 2014)), road traffic (DATEX, DATEX II (CEN, 2011a)), other soft modes or geographic references for infrastructure references (GDF (ISO, 2011), OpenStreetMap, INSPIRE). Additionally, a public transport elements physical and geographic description data referencing standard named IFOPT was issued in 2007. IFOPT is now embedded in Transmodel and complements NeTEx for the detail description and exchange of the public transport stop points and the stop area. Current standardization efforts at ISO aim for IFOPT and Transmodel to be compatible with GDF (road infrastructure description and exchange).In addition to these efforts, other initiatives have been widely adopted by different cities, providing part or nearly all the functionalities as the standards mentioned above. GTFS (General Transit Feed Specification) is an example of such a *de facto* adopted formats.

Different attempts have been made for proposing an IT architecture platform of reference that –based on open technology, the definition of common mechanisms, standard rules and protocols in the processes of interface design, communications specifications and installation – gives the possibility to use public transport data anywhere in Europe. Other national initiatives like the German project IP-KOM ÖV aim at the development of a set of interfaces based on existing standards between enduser applications, public transport information servers including real-time and PT vehicles.

4. The OPTICITIES project

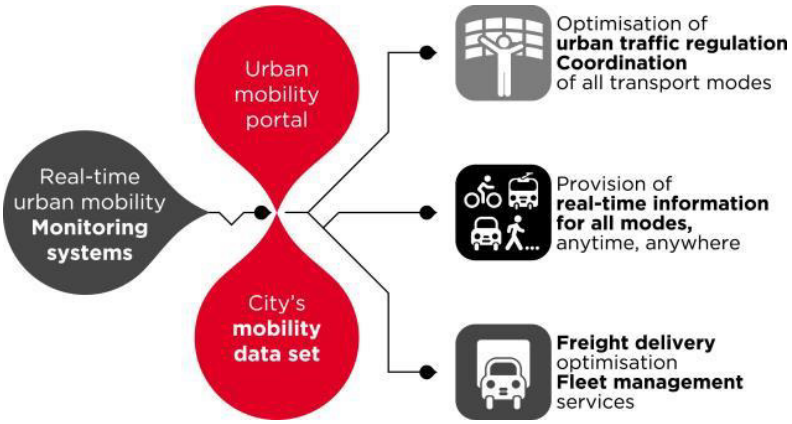

Fig. 1. OPTICITIES overall vision.

The OPTICITIES (Optimise Citizen Mobility and Freight Management in Urban Environments) project is one of the responses to the need for a harmonized urban mobility dataset. OPTICITIES is an ongoing FP7 project specifying a vision of optimized urban mobility at the focal point of user needs, urban mobility public policy, and business models of service providers, vision which can be seen in Fig. 1. The main objectives of the project are:

- Set up high level services for travelers and urban logistics, addressing user needs and urban mobility public policy.
- Support mobility policy and an open market for business development around urban ITS, through a contractual framework between public – private actors.
- Define standard and architecture to foster interoperability among cities and among travel modes.
- Set up a comprehensive data mobility store in European cities controlled by public stakeholders.
- Develop innovative services managed by the private sector or public stakeholders using the urban mobility data store, supported by an adapted contractual framework.

From the point of view of the technical challenges posed to achieve these objectives, the expected major breakthroughs in terms of innovation are the following:

- Consolidation of multiple sources of urban mobility data from all modes (network topology; theoretical, real-time and predictive schedules). Based on existing standards (Transmodel, SIRI, Netex, IFOPT, Datex II) the practical connections between them will be specified.
- European interoperability of urban mobility data and mobility solutions. Interoperability of traveler information applications with various urban datasets: different apps working in different environments.
- Provision of real-time information for all modes, available anytime, anywhere: the multimodal urban navigator and the journey assistant.
- Continuity of services between traveler mobility applications and in-car GPS.
- New monitoring systems for urban freight, multimodal data in large cities, road works.
- Development of urban multimodal GPS.
- Development of real-time multimodal management and dynamic car pooling.
- Integration into traffic management systems of 1h traffic prediction
- Development of high level freight information services.

5. OPTICITIES Open ITS task methodology

In the context of urban mobility applications, standardization provides confidence in the ability to build and deploy smart city and smart mobility applications and infrastructures. It also contributes to reducing the dependence of data silos, in which each entity that operates in the city and the region holds the data. The OPTICITIES Open ITS task aims at specifying a reference architecture and developing a conceptual interoperability framework for urban mobility support standards. Current relevant existing standards are mapped in this framework. This ensures interoperability between OPTICITIES system and entities and many levels, with the objective that data and information can always be exchanged at the appropriate level.

Particular activities performed in the context of this task have the overall objective of identify the aspects that are relevant to the selected number of interoperability cases in OPTICITIES, and go from the currently deployed systems to an interoperable framework of urban multimodal data management. The final step is the contribution of the results related with this interoperable framework into the ongoing activities at different standardization groups. This may include development of new standards, extensions or recommendations on existing standards to address the identified gaps, and so on. Several of the OPTICITIES partners are actively involved in CEN and ISO standardization groups, such as the CEN TC278 WG3 on public transport or the WG8 on road traffic data. Feedback from the project's findings is incorporated directly in the ongoing activities of these groups by different means.

One of the main challenges of OPTICITIES is to provide a consistent way to integrate different kinds of data related to urban mobility. Urban traffic data, interurban traffic data, railway data and public transport data, just to mention a few, have been traditionally developed separately. Their supporting standards have also been drafted separately from each other, which means that mobility managers have had to deal with different datasets, even when referring to the same element of the network. A bus stop is a component in a public transport line, with its associated bus lines, schedules and real time passing times, for example. But that same bus stop is a point in a street or road link, with its associated number of lanes, nearby traffic lights, real-time traffic volume, etc. And yet it is also a geographical point in the city, with its walkway, nearby points of interest, etc.

So far, there has been no successful specification on cross-referencing all these different datasets. Given the variety of data from different sources and different purposes at each city and the variety of supporting standards and related data management elements' specifications, it seems natural that the first step must be the definition of a common element to use as a reference for all the data. This common data reference would facilitate joint operation with several different datasets (such as those the cities are using now, in the cases when applicable). The key aspect is to define the types of objects that can be used in this common reference. If we look at the data characteristics in the different urban data management systems, it seems that good candidates for referencing are objects that belong or at least are very close to a static class. Elements of topographic nature, or of a very long cycle life, such as: the road infrastructure, PT stops, Car parking areas, Bike parking areas, Points of Interest, …

Of course, once these objects have been defined and identified, it is also important to consider that the key point of this reference data is that it can be linked to the several "local" datasets. In some cases, these objects may be directly referenced (point locations, for example), but in others definition of these objects may be different depending on the "local" dataset used. It is necessary to find a way to make these links, so they can be connected and referenced in a consistent way for the applications using the dataset. One of the ongoing activities at the standardization groups is focused on specifying the links between different datasets and their corresponding supporting standards. This activities mirror in fact one of the main tasks in the OPTICITIES Open ITS activity, and its simplified dataset interaction proposal can be seen in Fig. 2.

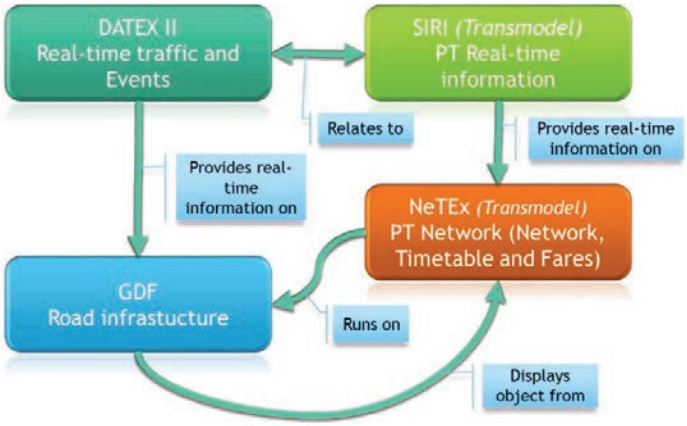

Fig. 2. Example of OPTICITIES simplified standards interactions.

These sets of common objects are the basis of another key element of contribution to standards, which is the specification of data management profiles. Profiles are an additional document to the standard which specifies additional rules for implementation in a given context. The profile contains information such as: details of used services, details of the objects used in an exchange, details on the options proposed by the standard, details on optional elements, etc. Additionally, profiles can be accompanied by the definition of a specific testing procedure to assess the conformance of the implemented solution with the profile standard.

From a practical point of view, profiles can be seen as an implementation guideline for a certain standard. Instead of having to face the challenge of analysing the whole standard, discover the relevant parts for a given application, and then adjusting optional values and parameters for the intended application, profiles can be specified to address the needs of a particular application and then used for any subsequent similar initiative.

In the case of Madrid, the objective is to address the integration of different providers and operators' data in a single common platform. This implies the use of both legacy and new components, and the need to consider a variety of data types and formats. The resulting dataset will manage integrated real-time data for all the Madrid city and region.

These activities are directly related with ongoing standardization work at CEN and ISO. The specific work in OPTICITIES, specifying the connection data elements between the major urban mobility standards such as IFOPT, Transmodel and GDF provides an immediate link to these standardization activities. The CEN/ISO activities are focused on the extension of GDF, in response to the need of a local and higher accuracy data to support the specification and deployment of Cooperative ITS services, and the update of the interface with the Transmodel standard to take into account public transport data.Thus, revisions of the standards currently under way can incorporate the results of the OPTICITIES project.

6. Results

For the purposes of more clearly specifying the standards profiles, and in general urban mobility data structures, in the context of urban data management in OPTICITIES, it is possible to identifyfour main categories:

- Land and infrastructure fixed or reference data describing the topography, transport infrastructure, long-term land uses, etc.
- Fixed mobility service related objects describing the networks, the services and facilities: data with long life cycles.
- Scheduled mobility services: operating services data, which can be known in advance, but that could change due to different reasons.
- Real-time data and control data. The former describing the current state of the network and services and also the events and consequences affecting them: these data only complement the real time data by providing additional real-time updates. The latter describes the control actions (or requirements for control action) that are decided as a consequence to the real-time status of the road and PT network. Both real-time and control data have very short life cycles.

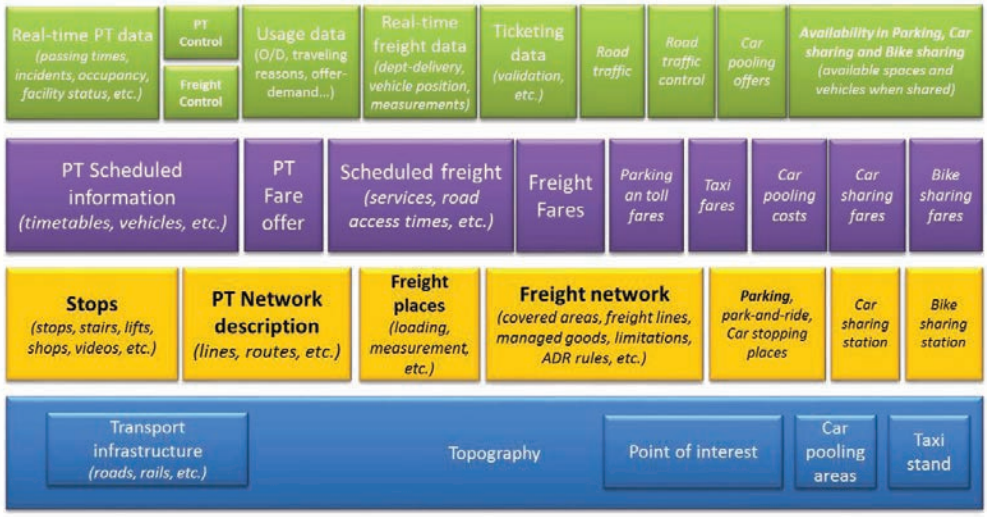

Fig. 3. OPTICITIES proposed data categories.

Of course, taking into account the variety of data available at the cities, and the urban mobility services considered, from traffic information to freight management, results in a much more complex data categorization, an outline of which can be seen in the Fig 3. The layered structure has been defined to convey the idea of data that could be used as reference at the lower layers and increasingly time-dependent and dynamic data in upper layers. This layout also helps identifying supporting standards, connections between data elements of similar scope, and maybe more importantly, will make it easier to define complete service profiles including all types of relevant data (Alfonso and Duquesne, 2014).

In the case of Madrid, the starting point of the data categories to be considered in the development of the common dataset and the supporting implementation guidelines was the following resulting target data subset.

Table 1. Selected target data subset of the Madrid scenario.

Object name	Name	Type	Description
App	name	String	Application name
	kmls	KML[]	Array of objects of the type “KML”
KML	name	String	Name of the KML file
	description	String	Description of the KML file
	URL	String	URL where the KMLfile is
	updateDate	DateTime	KML file last update date
LastDatesUpdate	updateDate	DateTime	Date of the last topology update
	updateKmlDate	DateTime	Date of the last KML files update
POI	codPoi	String	Code of the point of interest
	address	String	POI address
	openTime	String	Time in which the POI is open to public
	contact	String	Contact person details
	latitude	Float	POI latitude
	longitude	Float	POI longitude
Company	codCompany	String	Company code
	name	String	Company name
Mode	codMode	String	Transport mode code
	name	String	Transport mode name
Line	codLine	String	Line code
	shortDescription	String	Line short description
	description	String	Line name
	codMode	String	Transport mode code it belongs to
	shortItinerary	Itinerary[]	Array with the two itineraries (single and return)
	updateDate	DateTime	Date of the last topology update
	updateKmlDate	DateTime	Date of the last KML files update
	nightService	Int	Flag to indicate if the line has a night service.
Stop	codStop	String	Stop/station code
	shortCodStop	String	Simplified stop code
	codMode	String	Transport mode code it belongs to
	name	String	Stop name
	address	String	Stop physical address
	codMunicipality	String	Municipality code where the stop is
	coordinates	Coordinates	Stop coordinates
	access	Int	Indicates the accessibility status of the stop
	park	Int	Indicates the parking status of the stop
	nightLinesService	Int	Flag to indicate if the stop has a night service.
	codLines	String[]	Array of codes of the lines stopping at this stop

One of the objectives of the OPTICITIES project is the promotion in the use of standards for the data categories considered. However, the use of CEN/ISO standards is not straightforward, and it may not respond to the cities restrictions or requirements at the moment. This is why OPTICITIES proposes in its overall view of the profiles implementation guidelines a number of different scenarios, which can be applicable to any city, regardless of the current systems implemented and desired end-scenario.

- A long term deployment scenario, which follows the recommendations and initiatives from the standardization groups.
- An intermediate partial Open Data oriented transitional scenario, which considers some of the recommendations and initiatives from the standardization groups, but optional standards for certain cases.
- A transitional scenario, which considers different data formats for data categories, as long as it still fulfils certain interoperability requirements.

In the case of Madrid, the most practical approach for the dataset corresponds to the intermediate open data approach, in which GTFS is an option for the support of the mobility applications data, as can be seen in Fig. 4. The figure shows the relevant data categories as described in Fig. 3, with the supporting standards over-imposed on them. The most important factor in this choice was the fact that GTFS has already been adopted by a significant number of the public transport operators in the region of Madrid, and has been the basis for the integrated data exchange platform.

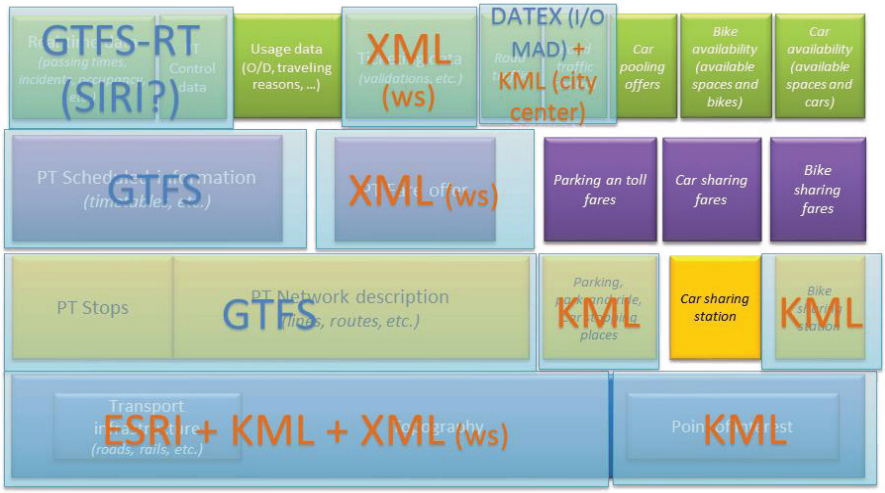

Fig. 4. Simplified deployment data formats for the Madrid scenario.

Based on the ongoing developments in OPTICITIES, however, it is considered possible that the target data format scenario deployment for Madrid in the long term is more directly aligned with CEN/ISO proposals.The necessary steps for the transition are currently being assessed in OPTICITIES, but in any case it could result in a long term specification of data and supporting standards similar to what can be seen in Fig. 5.

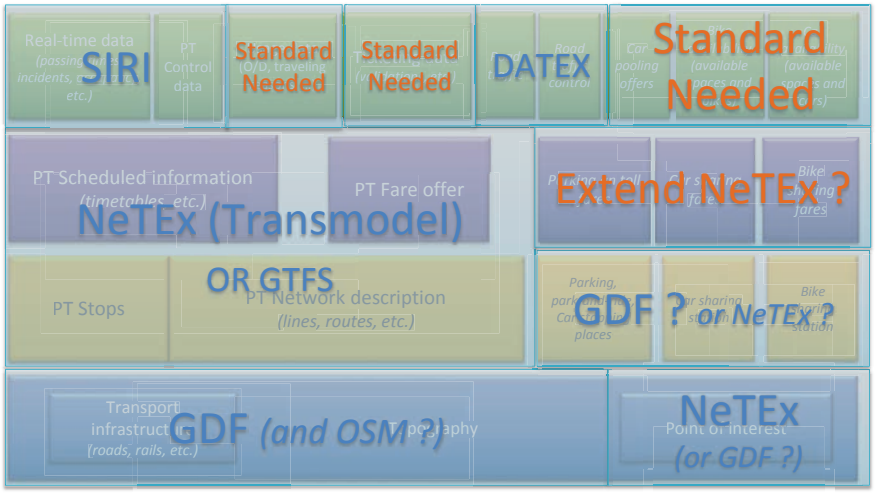

Fig. 5. Long-term deployment target data formats for the Madrid scenario.

7. Discussion & conclusion

There are many different aspects which influence urban mobility, and the technical aspects are only one of many factors that need to be considered to handle the challenges of transport in the cities. However, it is also clear that management of mobility data plays an important role, as it impacts the whole urban service chain from data collection to service user notification. The OPTICITIES project aims at providing a comprehensive set of elements that will help definition and deployment of data platforms and services to achieve true interoperability and scalability of different key urban mobility services, such as public transport information, traffic information,….

Taking into account data availabilities in the cities, and the intended traffic information services, relevant data categories for public transport, road traffic and freight services have been identified, together with the supporting standards.Working on the idea of local implementations a number of use cases and the corresponding data management profiles have been defined. These profiles have a strong link with the identified standards, and it will be a key task to specify the methodology by which to implement these standard profiles.

Now that the OPTICITIES interoperability use cases have been identified, it is necessary to analyse in more detail the extent in which data sets have been implemented in the cities, and the corresponding standards chosen for this implementation. The objective of this activity is to have a clear idea of up to which extent necessary data for the OPTICITIES use cases is already available at the cities, together with the supporting standards. As the standard profiles are getting more detailed, it will be necessary to specify the appropriate testing methodologies for ensuring compliance with these profiles.

Most importantly, these activities are directly related with ongoing standardisation work at CEN and ISO. The specific work in OPTICITIES, specifying the connection data elements between the major urban mobility standards such as IFOPT, Transmodel and GDF provides an immediate link to these standardisation activities. Thus, revisions of the standards currently under way will incorporate the project results when more detailed specifications on data formats and interfaces are defined in OPTICITIES, providing one of those rare chances in which a project's development timing facilitates standards drafting.

On the other hand, focusing in the particular case of Madrid, some relevant requirements are related to the integration of legacy and new elements. This allows OPTICITIES to broaden the scope of the data harmonization activities by including additional types of data in the intended common platform. In addition to the data/technically--oriented approach to data exchange specification of profiles, considerations will have to be included for

administrative aspects related to the services and systems, as well as to the long term strategies/policies of the entities involved. Other aspects to be considered will have to include the potential impact of any migration strategy to different target scenarios, in terms of material and human resources investment, assessment, development, validation and the final conformance tests. The resulting recommendations will be useful in the specification of implementation guidelines that will be meaningful beyond the timeline of the project.At the same time, these will contribute to the specification of more useful and comprehensive standard profiles and their supporting implementation documents.

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